# OMNInet Testbed, GENI, and International Optical Networking Services

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**Optical Network Testbeds 3 (ONT3)**
**Tokyo, Japan**

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iCAIR

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# Introduction to iCAIR:



Accelerating Leading Edge Innovation and Enhanced Global Communications through Advanced Internet Technologies, in Partnership with the Global Community

- **Creation and Early Implementation of Advanced Networking Technologies - The Next Generation Internet All Optical Networks, Terascale Networks**

- **Advanced Applications, Middleware, Large-Scale Infrastructure, NG Optical Networks and Testbeds, Public Policy Studies and Forums Related to NG Networks**

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# Traditional Networking Architecture

- **Traditional Networking Architecture and Technology Has Been Designed To Support Relatively Few Communications Modalities, e.g., Voice, Video, Common Data.**

- **Today Internet Primarily Supports A Single "Best Effort" Service**

- **Infrastructure Implementations Have Been Expected to Last a Very Long Time - Many Years.**

- **Consequently, Traditional Networking Architecture Is Too Rigid Too Accommodate Change Quickly**

- **Traditional Designs Cannot Meet Emerging Requirements for 21st Century Services**

- **A Fundamentally New Architecture is Required**

# A Next Generation Architecture: *Distributed Facility*
## Enabling Many Types Network/Services

Environment: VO

Environment: Real Org1

Environment: Intelligent
Power Grid Control

Environment: RFIDNet

Environment: Bio Org

Environment:
Large Scale System Control

Environment: Global App

SensorNet

HPCNet

FinancialNet

R&DNet

GovNet1

MedNet

RFIDNet

PrivNet

BioNet

MediaGridNet

Environment: Sensors

Environment: Real Org

Environment: Real Org2

Environment: Gov Agency

Environment:
Control Plane

Environment: Lab
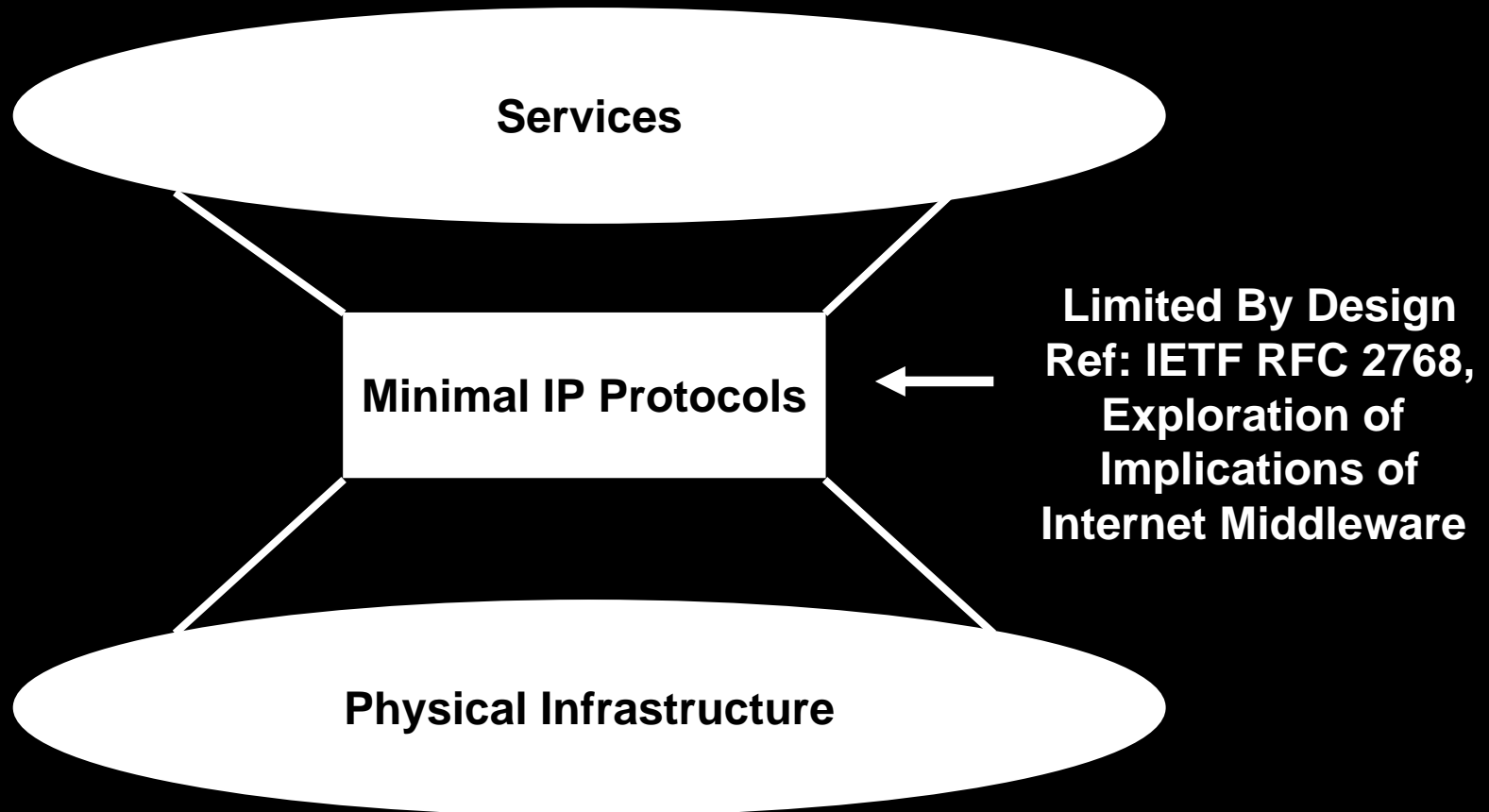
Environment:
International Gaming Fabric

Environment: Financial Org

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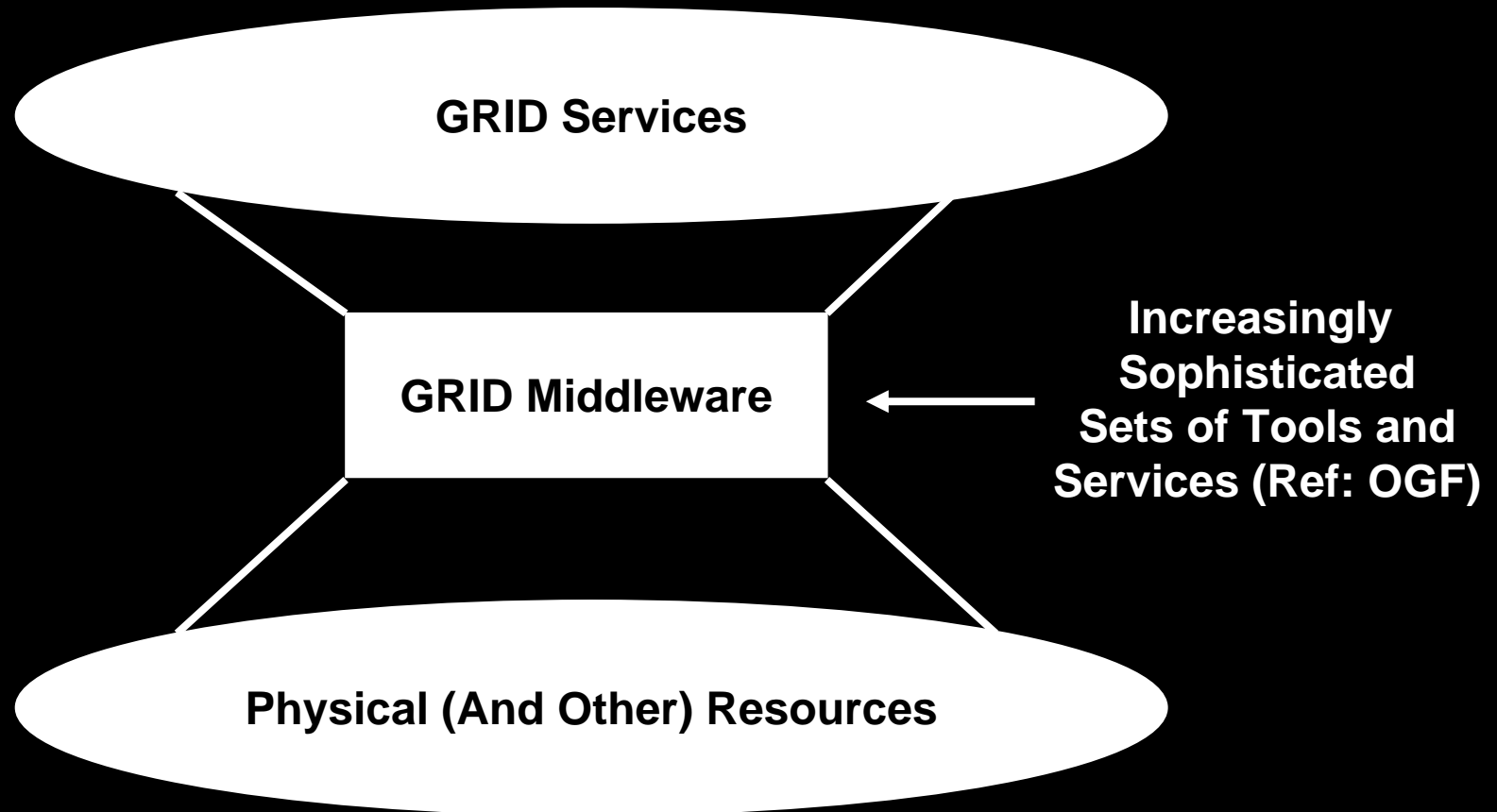
# A New Architecture

- **The Traditional Network Is Being Replaced**
- **A New Architecture Will Provide For New Communication Services Based on a New Foundation**
- **A Major Challenge To Advancement Is the Installed Base, Which Is A Barrier To Innovation**
- **For example, the Current Traditional Internet Constitutes a Barrier To Its Improvement**
- **The New Environment Must Provide Capabilities for Both On-Going Production and New Innovation**
- **The New Architecture Provides For Not a "Network" Design But Instead For A Large Scale Highly Distributed Facility That Can Change Instantaneously In Response To Changing Requirements.**

# Internet "Hour Glass" Design

# GRID "Hour Glass" Design



GRID Services

GRID Middleware

Increasingly Sophisticated Sets of Tools and Services (Ref: OGF)

Physical (And Other) Resources

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# GENI Facility

Distributed Services

Generalized
Management
And Control (GMC)

← A Key Resource

Middleboxes!

Physical Substrate
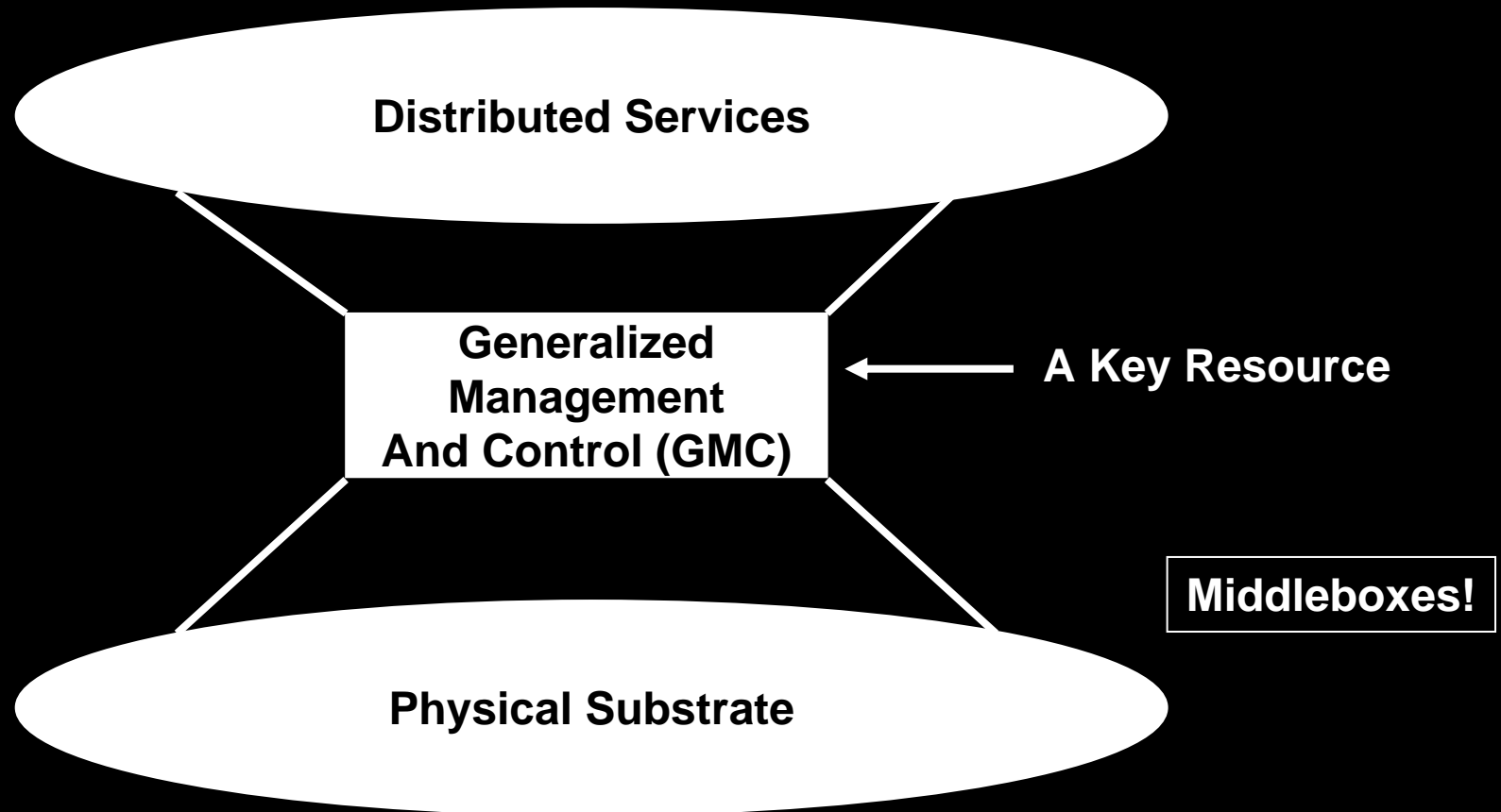
GMC = name space for
users, slices, resources, interfaces, access channels etc
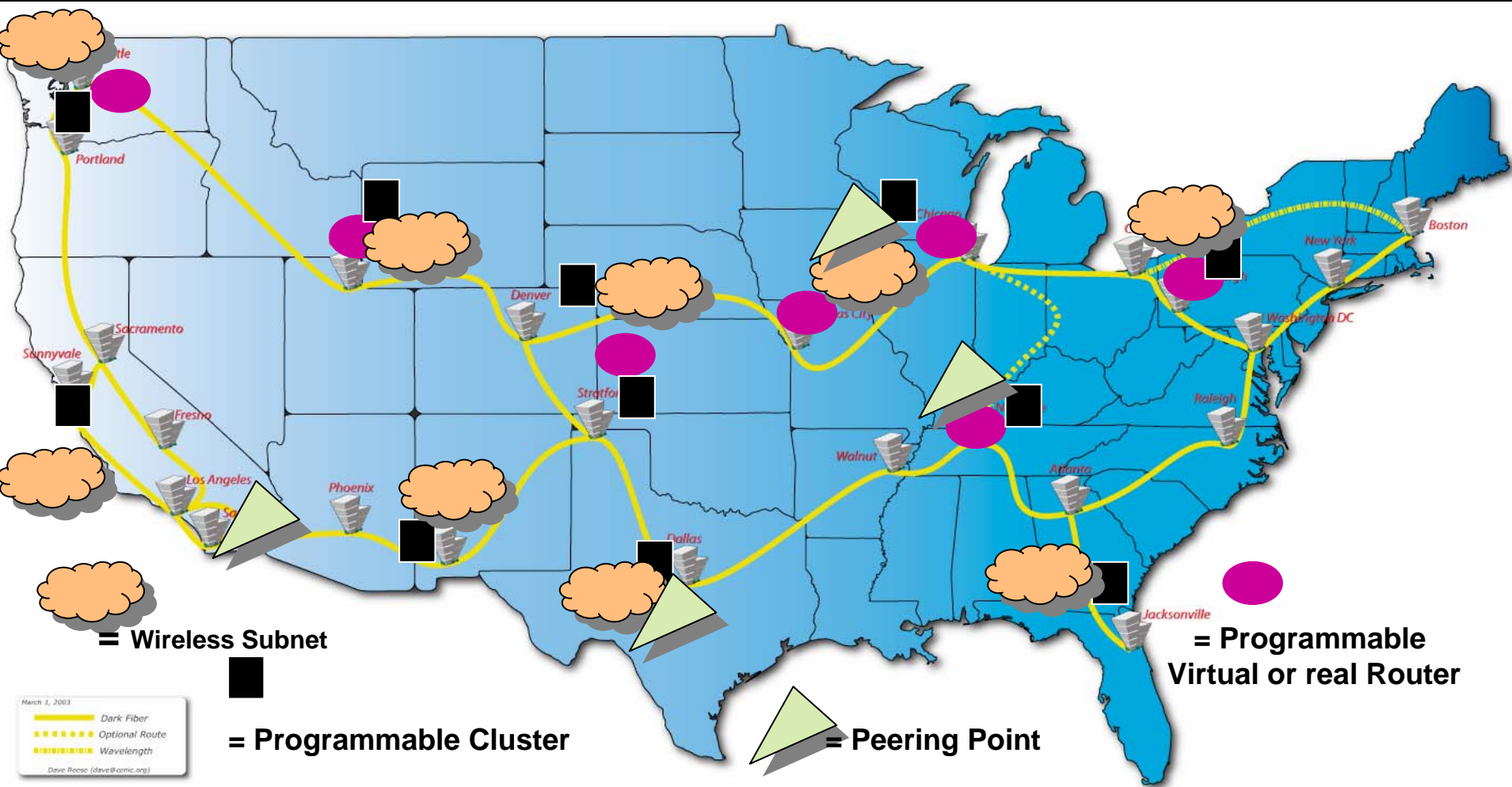
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# GENI Concepts

- **Physical Substrate: Accessible Hardware Resources**
- **Slice: Virtualized or Partitioned Resources**
- **Embedding: Slices are Embedded in Substrate**
- **Building Blocks: Nodes, Links, Subnets**
- **Software Management Framework: Enables Embedding in Substrate**
- **Generality: Programmability**
- **Fidelity: Exposure of The Appropriate Level of Abstraction (e.g., via APIs)**
- **User Access: Ability To Use Real User Traffic as Part of Experimentation**
- **Controlled Isolation: Ability to Access Legacy Internet**
- **Diversity and Extensibility: Ability To Experiment With Many Technologies None Exclusive**
- **Wide Deployment: Many PoPs**
- **Observability: Substantially Instrumented**
- **Sustainability: Partnership Federations**
- **Backbone Facilities, VMs, Net Prog Processor, Blades, Programmable Routers, Reconfigurable Virtual and real circuits, Dynamic Lightpaths**

**Source: Guru Parulkar**

# GENI+National Lambda Rail



**= Wireless Subnet**

**= Programmable Cluster**

**= Peering Point**

**= Programmable Virtual or real Router**

March 1, 2003

Dark Fiber
Optional Route
Wavelength

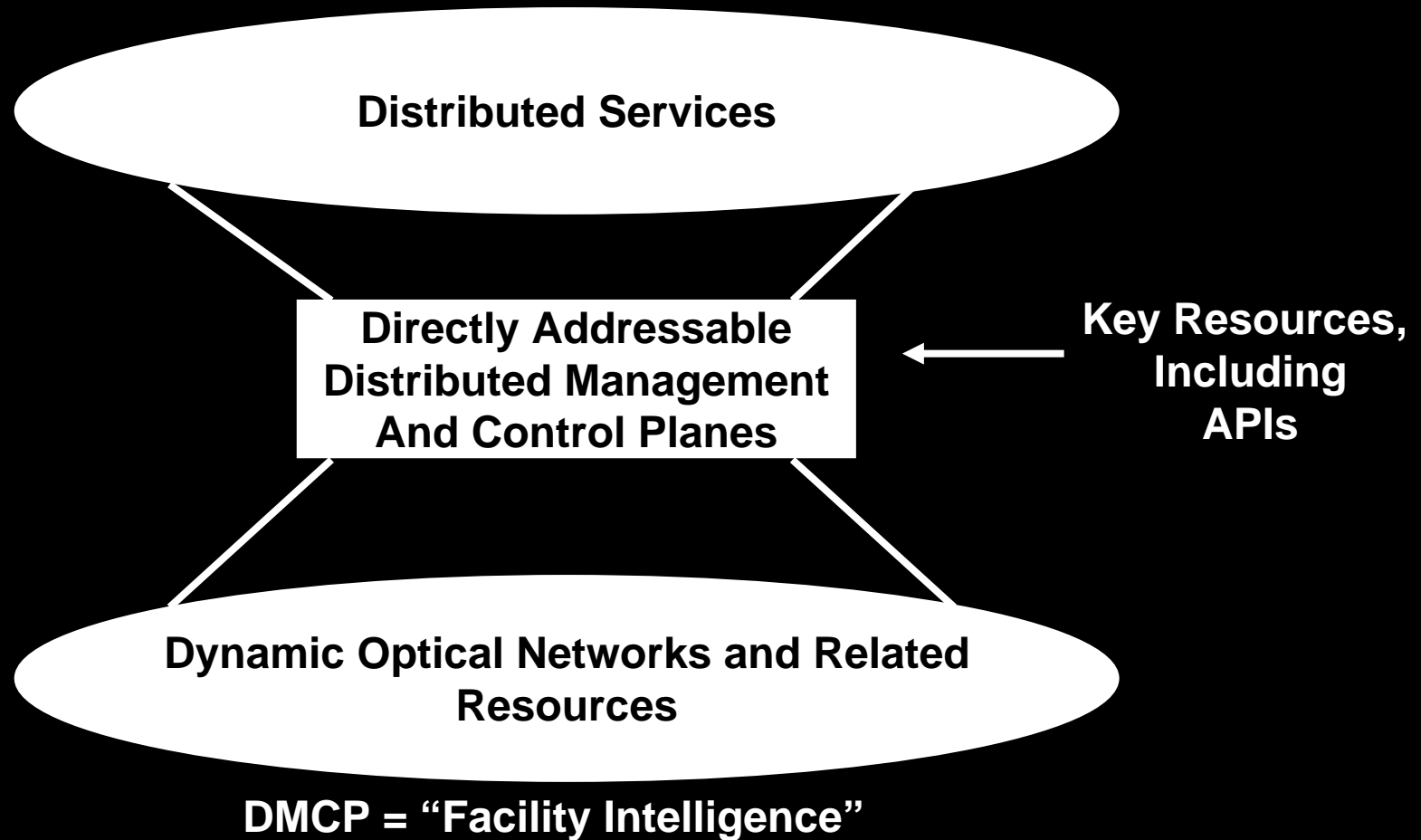Dave Reese (dave@cenic.org)

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# Implications for Optical Networks

- **Facilities Exist Today Which Reflect Many of These Principles**
- **These Facilities Reflect the Future of Communication Services**
- **A  Highly Distributed Facility ("Lambda Grid") Is Being Designed To Support Multiple Networks With Different Characteristics Each Supporting Multiple Highly Differentiated Services**
- **The Core of This Facility Will Be Based On Next Generation Agile "Intelligent" Optical and Photonic Technologies**
- **These Innovations Are Being Driven By Advanced Optical/Photonic Research Networking Organizations In Response To Application Demand and By New Innovations In Optics and Photonics**
- **The Future is Light!**

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# Global Lambda Integrated Facility

**Distributed Services**

**Directly Addressable Distributed Management And Control Planes**

**Key Resources, Including APIs**

**Dynamic Optical Networks and Related Resources**

**DMCP = "Facility Intelligence"**

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# Distributed Management and Control Planes

- **A Key Resource = "Intelligent" Optical/Photonic Technologies**
- **Intelligence Is Provided By New Types of *Highly Distributed* (vs Centralized) Management and Control Planes Oriented Toward New, Agile Photonic Devices**
- **These Photonic Devices Are Emerging from Research Labs**
- **Small Form Factor, Flexible, Low Power Consumption, More Easily Integrated, More Cost Efficient**

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# LambdaGrid Paradigm Shift

**Traditional Provider Services:
Invisible, Static Resources,
Centralized Management,
Highly Layered**
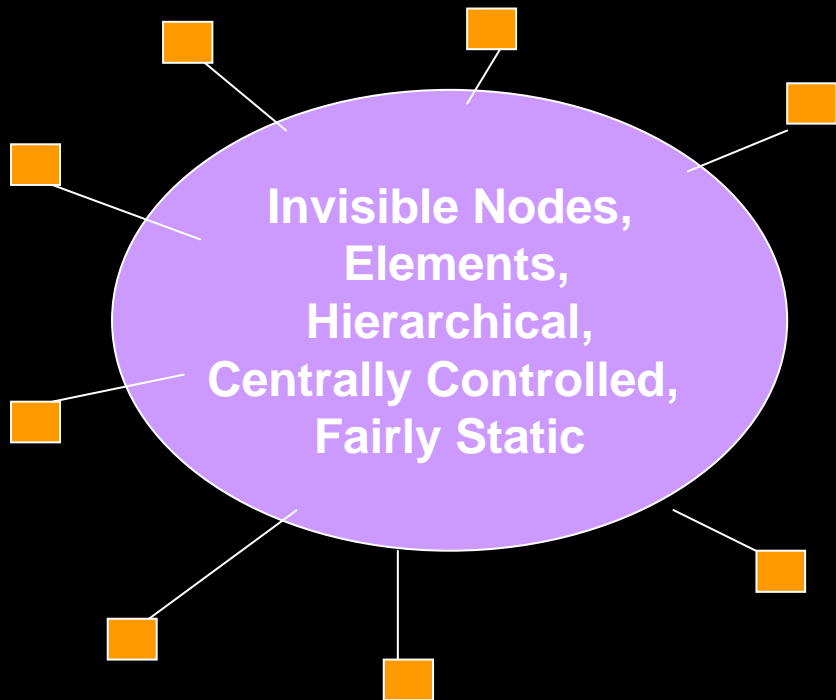
**Distributed Device, Dynamic Services,
Visible & Accessible Resources,
Integrated As Required, Non-Layered**

**Invisible Nodes,
Elements,
Hierarchical,
Centrally Controlled,
Fairly Static**

**Limited Services, Functionality,
Flexibility**
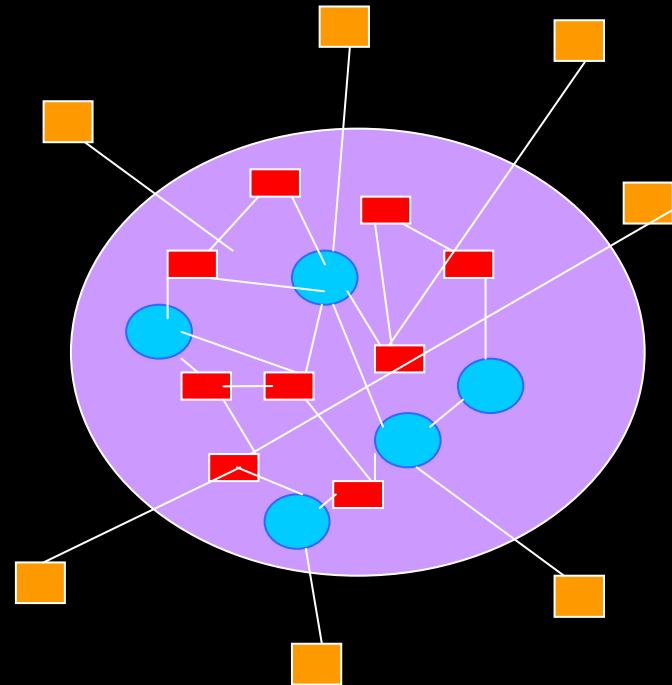
**Unlimited Services, Functionality,
Flexibility**

Ref: OptIPuter Backplane Project

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# Intelligent Application/Process Signaling

**Client Layer Control Plane: Communications Service Layer**
**Service Layer, Policy Based Access Control, Client Message**
**Receiver, Signal Transmission, Data Plane Controller,** Optical Layer Control Plane
**Data Plane Monitor**

IAS Server

UNI

Controller

Controller

Controller

Controller

I-UNI

CI

CI

CI

Client Data Plane Server

**Client Layer Traffic Plane**

**Optical Layer – Switched Traffic (Data) Plane**
**Multiiservice: Unicast, BiDirectional, Multicast,**
**Burst Switching**

**\* Also Control Signaling, et al**

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| HP-PPFS | HP-APP2 | HP-APP3 | HP-APP4 |
|---------|---------|---------|---------|
| VS | VS | VS | VS |

**Previously OGSA/OGSI, Soon OGSA/OASIS WSRF**

Lambda Routing:

Topology discovery,  DB of physical links

Create new  path, optimize path selection

Traffic engineering

Constraint-based routing

O-UNI interworking and control integration

Path selection,  protection/restoration tool -  GMPLS

**Architecture**

tcp

tcp

**ODIN Server Creates/Deletes LPs, Status Inquiry**

**Access Policy (AAA) Process Registration**

**Discovery/Resource Manager, Incl Link Groups**

**Addresses**

GMPLS Tools (with CR-LDP)

LP Signaling for I-NNI

Attribute Designation, eg Uni, Bi directional

LP Labeling

Link Group designations

System Manager

Discovery

Config

Communicate

Interlink

Stop/Start Module

Resource Balance

Interface Adjustments

**Process Instantiation Monitoring**

ConfDB

**OSM**

**UNI-N**

**Data Plane**

**Physical Processing Monitoring and Adjustment**

**Resource** | **Resource** | **Resource** | **Resource**

Control Channel monitoring, physical fault detection, isolation, adjustment, connection validation etc

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# Optical Dynamic Intelligent Network (ODIN)
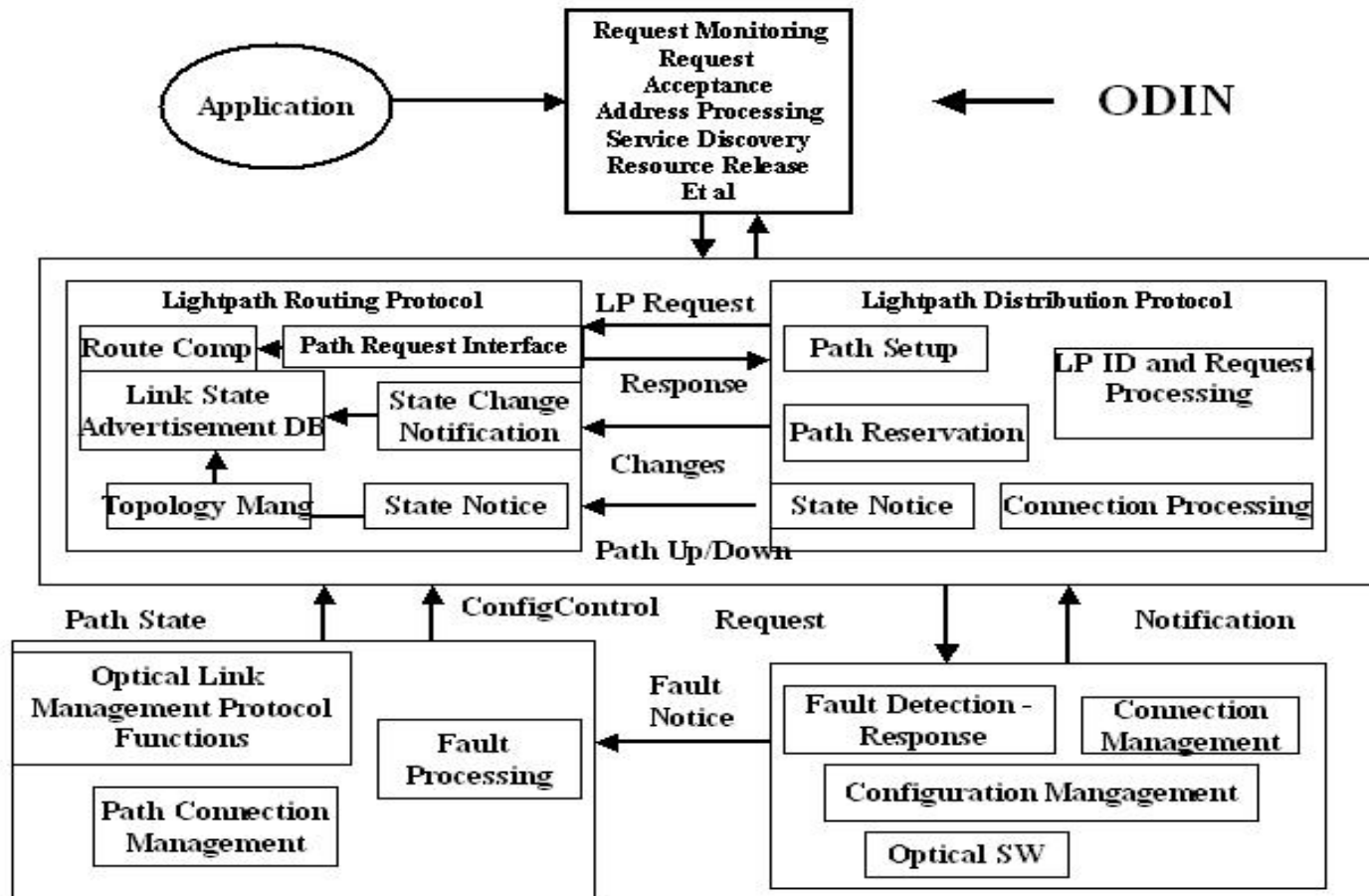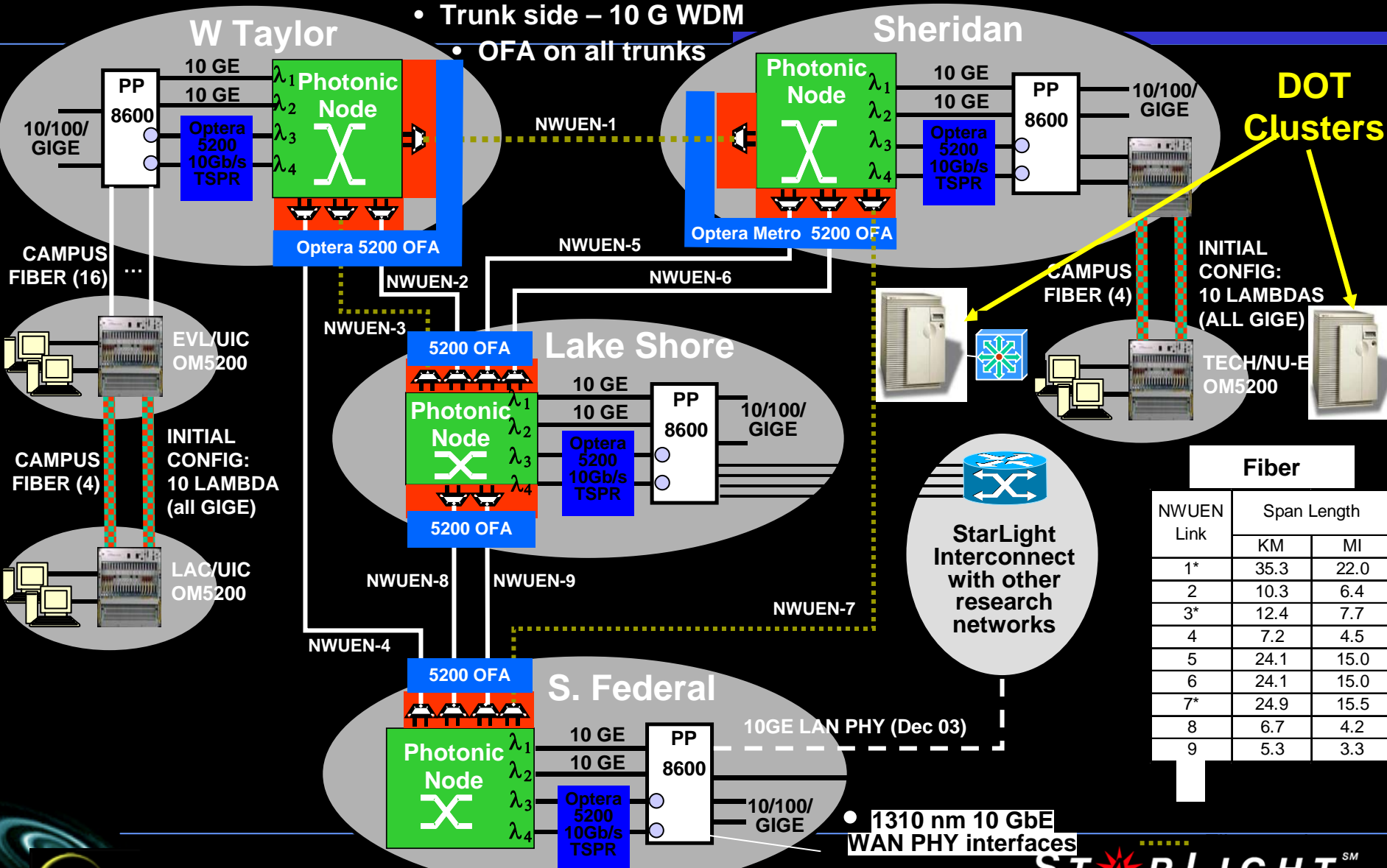
# OMNInet 1, 2, 3

- **OMNInet Phase 1**
  - **Multiple Architecture, Technology Issues Related to Carrier Challenges in Optical Core**
- **OMNInet Phase 2 (Extensions)**
  - **Multiple Architecture, Technology Issues Related to Large Scale e-Science Challenges Using Lambda Grids**
- **OMNInet Phase 3**
  - **Multiple Architecture, Technology Issues Related to Design and Implementation of Large Scale, Flexible, Distributed Environment**
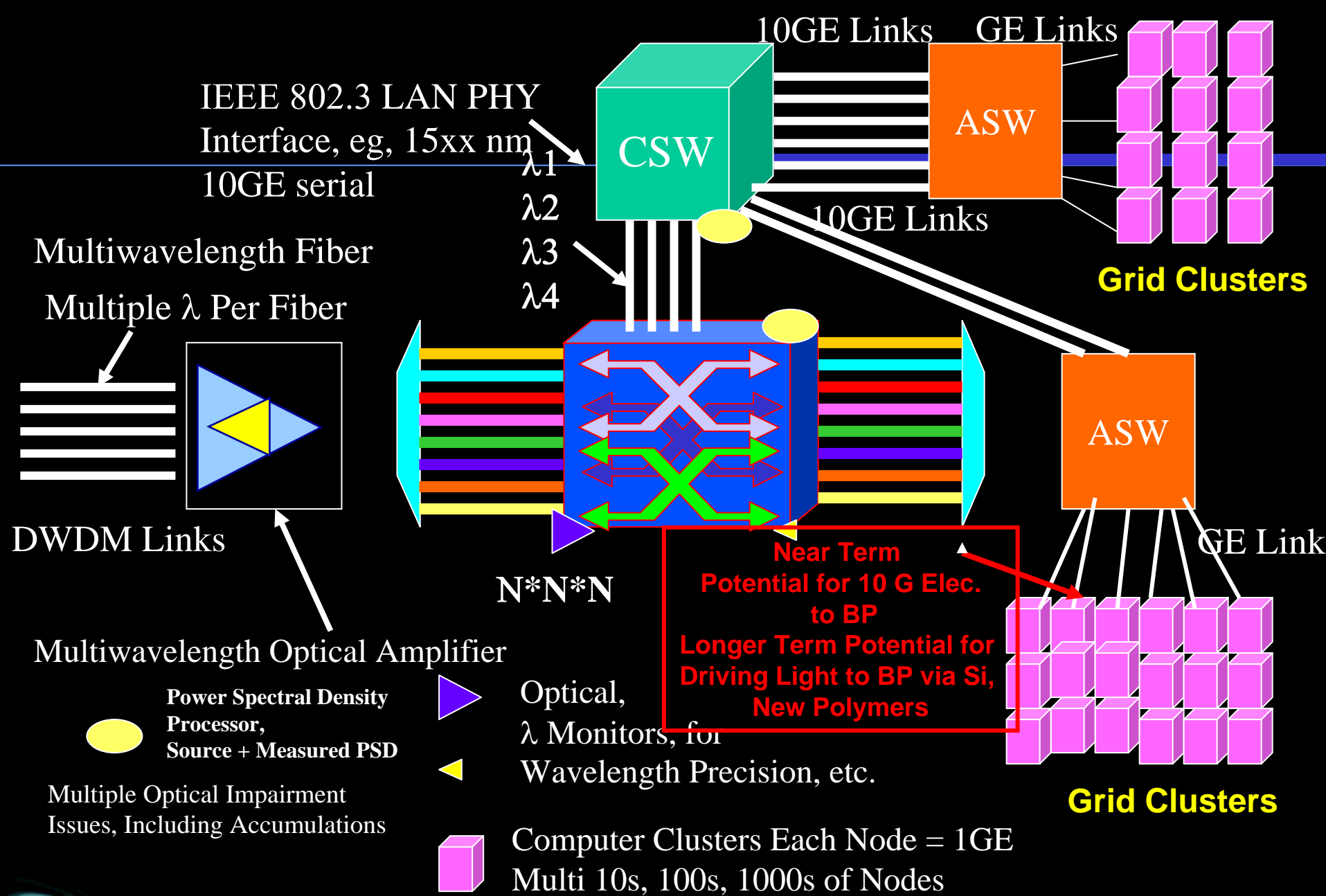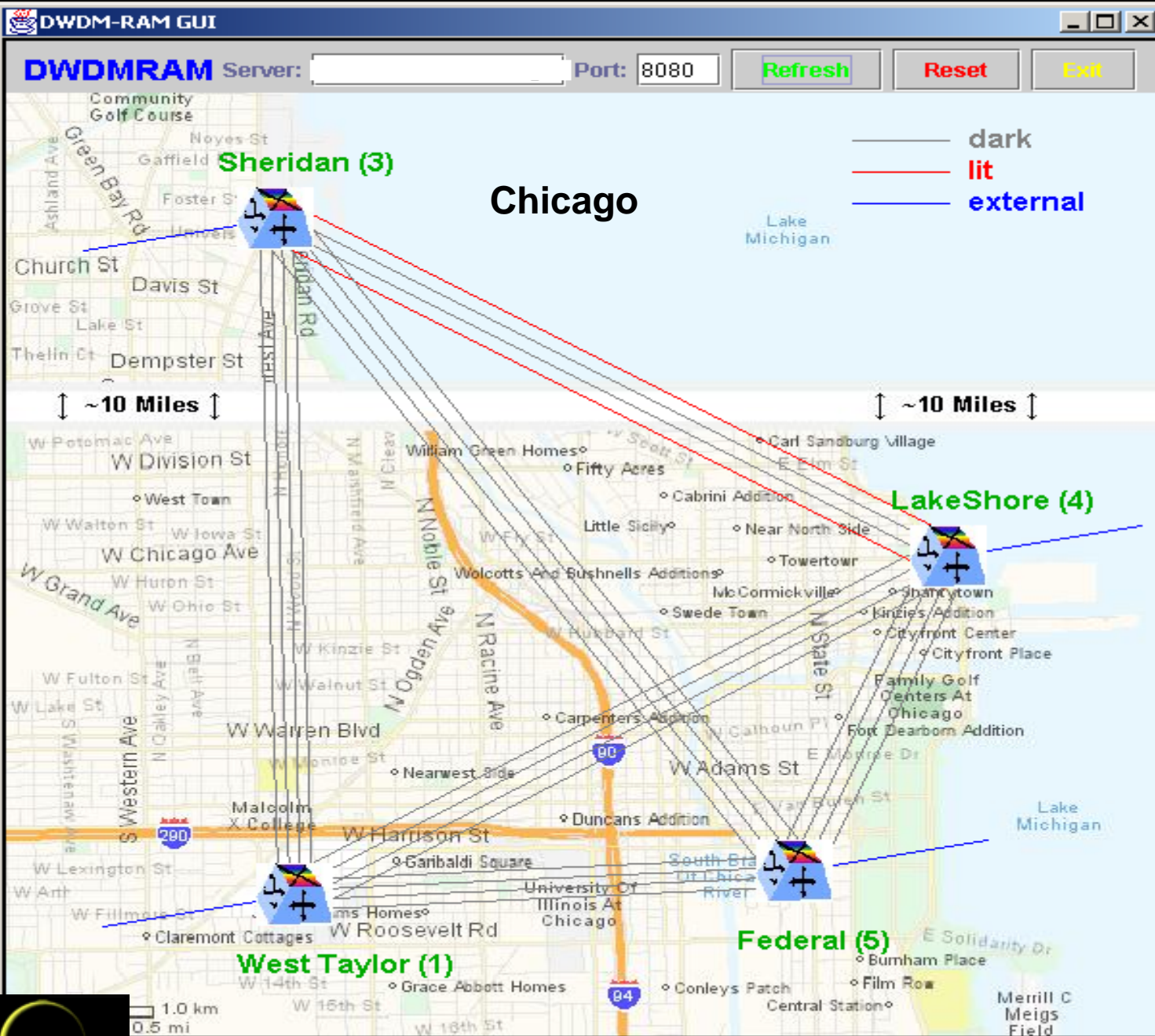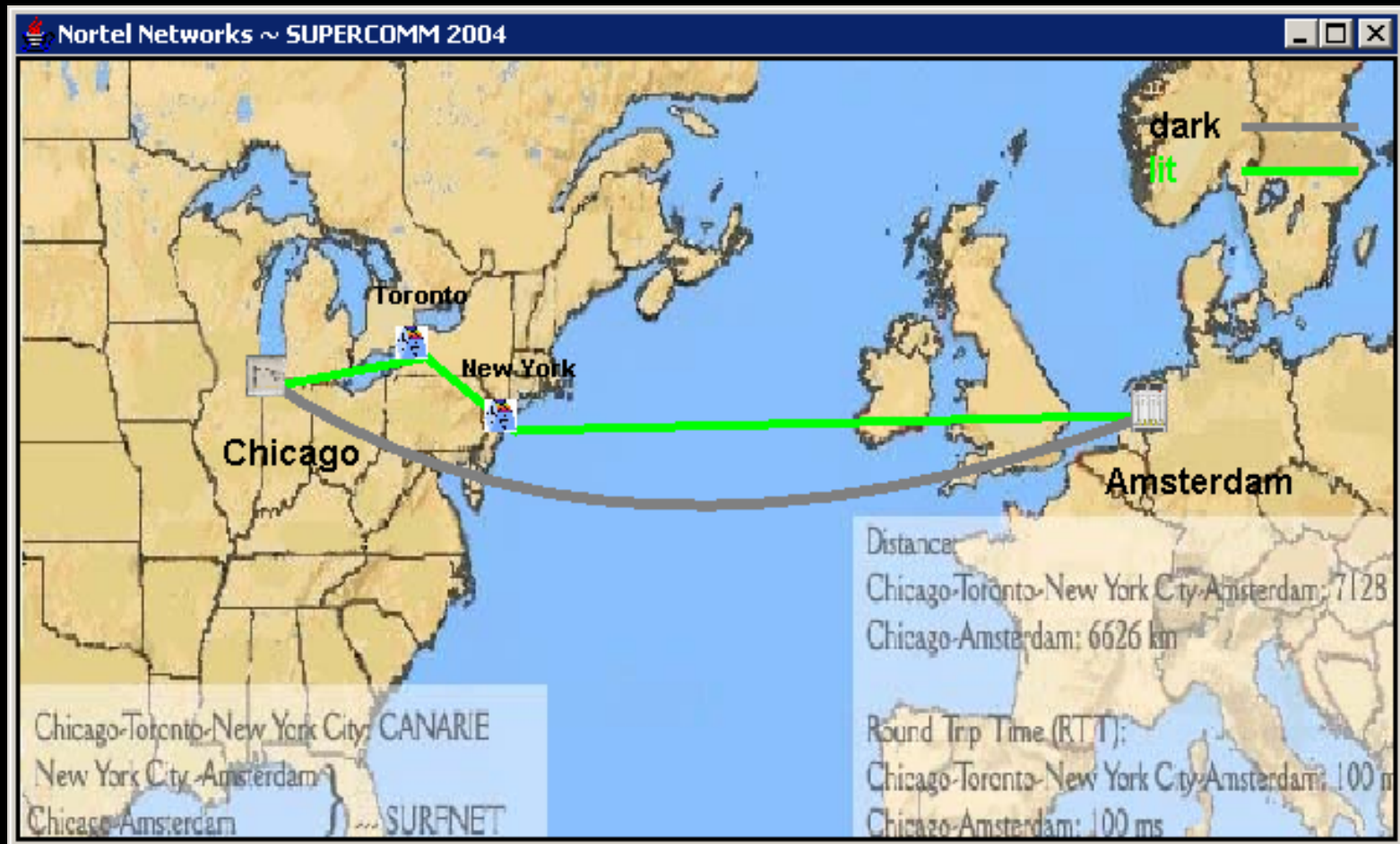
# OMNInet Network Configuration Phase 2: Many Promising Research Results

- 8x8x8$\lambda$ Scalable photonic switch
  - Trunk side – 10 G WDM
    - OFA on all trunks

**W Taylor**

PP 8600

10 GE
10 GE

10/100/GIGE

Optera 5200 10Gb/s TSPR

$\lambda_1$ $\lambda_2$ $\lambda_3$ $\lambda_4$ **Photonic Node**

Optera 5200 OFA

NWUEN-1

**Sheridan**

**Photonic Node** $\lambda_1$ $\lambda_2$ $\lambda_3$ $\lambda_4$

Optera 5200 10Gb/s TSPR

PP 8600

10 GE
10 GE

10/100/GIGE

Optera Metro 5200 OFA

**DOT Clusters**

CAMPUS FIBER (16) ...

NWUEN-2

NWUEN-3

NWUEN-5

NWUEN-6

CAMPUS FIBER (4)

INITIAL CONFIG: 10 LAMBDAS (ALL GIGE)

EVL/UIC OM5200

5200 OFA

**Lake Shore**

**Photonic Node** $\lambda_1$ $\lambda_2$ $\lambda_3$ $\lambda_4$

Optera 5200 10Gb/s TSPR

PP 8600

10 GE
10 GE

10/100/GIGE

5200 OFA

TECH/NU-E OM5200

CAMPUS FIBER (4)

INITIAL CONFIG: 10 LAMBDA (all GIGE)

LAC/UIC OM5200

**StarLight Interconnect with other research networks**

NWUEN-8

NWUEN-9

NWUEN-7

NWUEN-4

5200 OFA

**S. Federal**

**Photonic Node** $\lambda_1$ $\lambda_2$ $\lambda_3$ $\lambda_4$

Optera 5200 10Gb/s TSPR

PP 8600

10 GE
10 GE

10/100/GIGE

10GE LAN PHY (Dec 03)

- 1310 nm 10 GbE WAN PHY interfaces

| NWUEN Link | Fiber Span Length | |
|---|---|---|
| | KM | MI |
| 1* | 35.3 | 22.0 |
| 2 | 10.3 | 6.4 |
| 3* | 12.4 | 7.7 |
| 4 | 7.2 | 4.5 |
| 5 | 24.1 | 15.0 |
| 6 | 24.1 | 15.0 |
| 7* | 24.9 | 15.5 |
| 8 | 6.7 | 4.2 |
| 9 | 5.3 | 3.3 |

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# SC2004 Demonstration: Control Challenge

**Default configuration:**

**Tribs can be moved as needed**

**Could have 2 facing L2 SW**

Only TFEC link can support OC-192c (10G Wan) operation

Non -TFEC link used to transport Ge traffic

**600 N. Federal**

Optical Switch

**1890 W. Taylor**

1x 10G Wan

**High Performance L2 Switch**

Optical Switch

1 x 10G Wan

**High Performance L2 Switch**

**Ge (x2)**

**Ge (x2)**

Optical Switch

Optical Switch

1 x 10G Wan

**High Performance L2 Switch**

1 x 10G Wan

**High Performance L2 Switch**

**Ge (x2)**

**Ge (x2)**

**710 North Lake Shore Drive**

**750 North Lake Shore Drive**
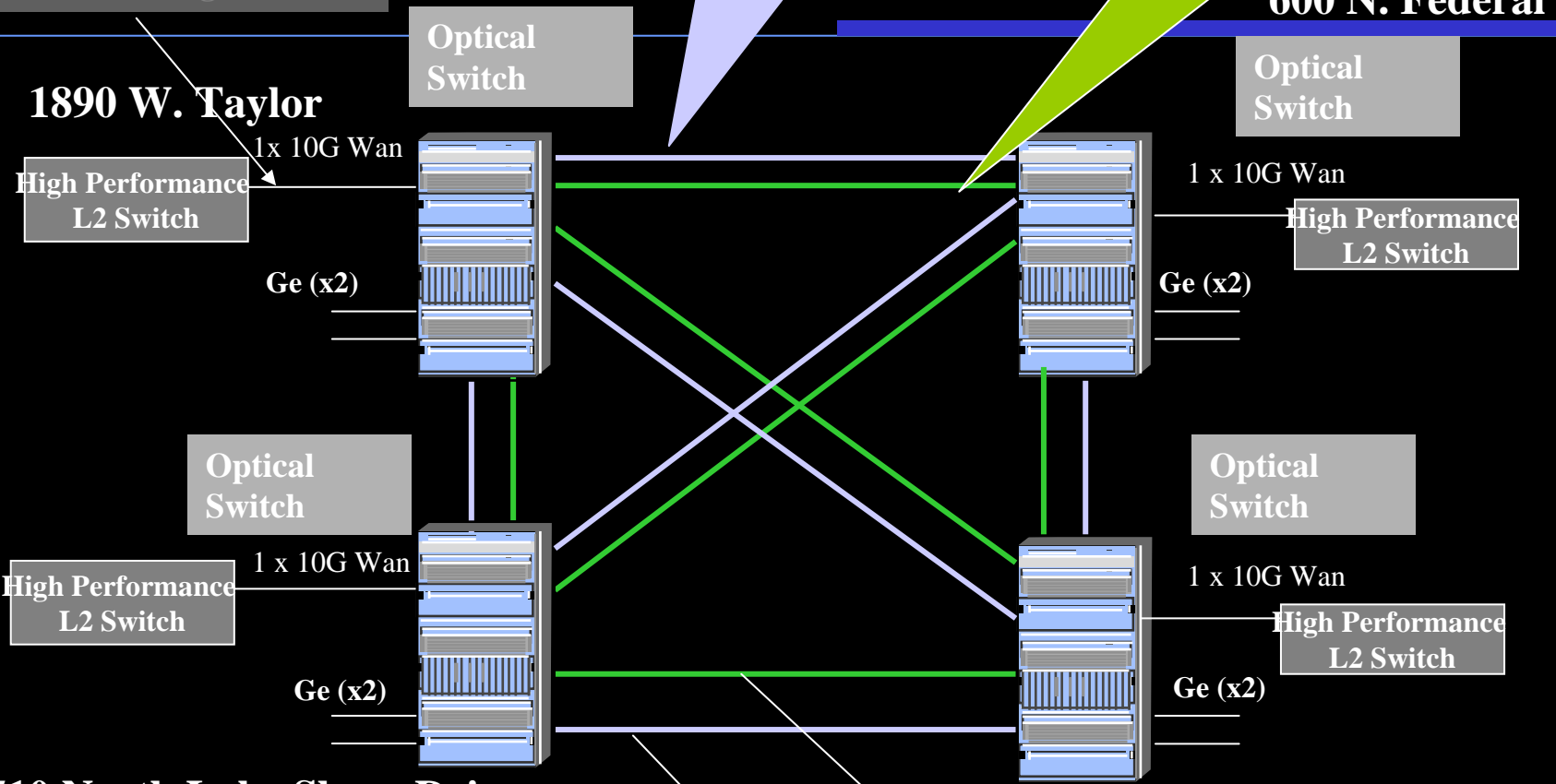
**Non - TFEC Link**

| Trib Content | |
|---|---|
| OC-192 – with  TFEC | 16 |
| OC-192 – without TFEC | 12 |
| Ge | 8 |
| OC-48 | 0 |

**TFEC Link**

**TFEC = Out of band error correction**

**OMNInet 2005**

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# New Testbed Site Fiber
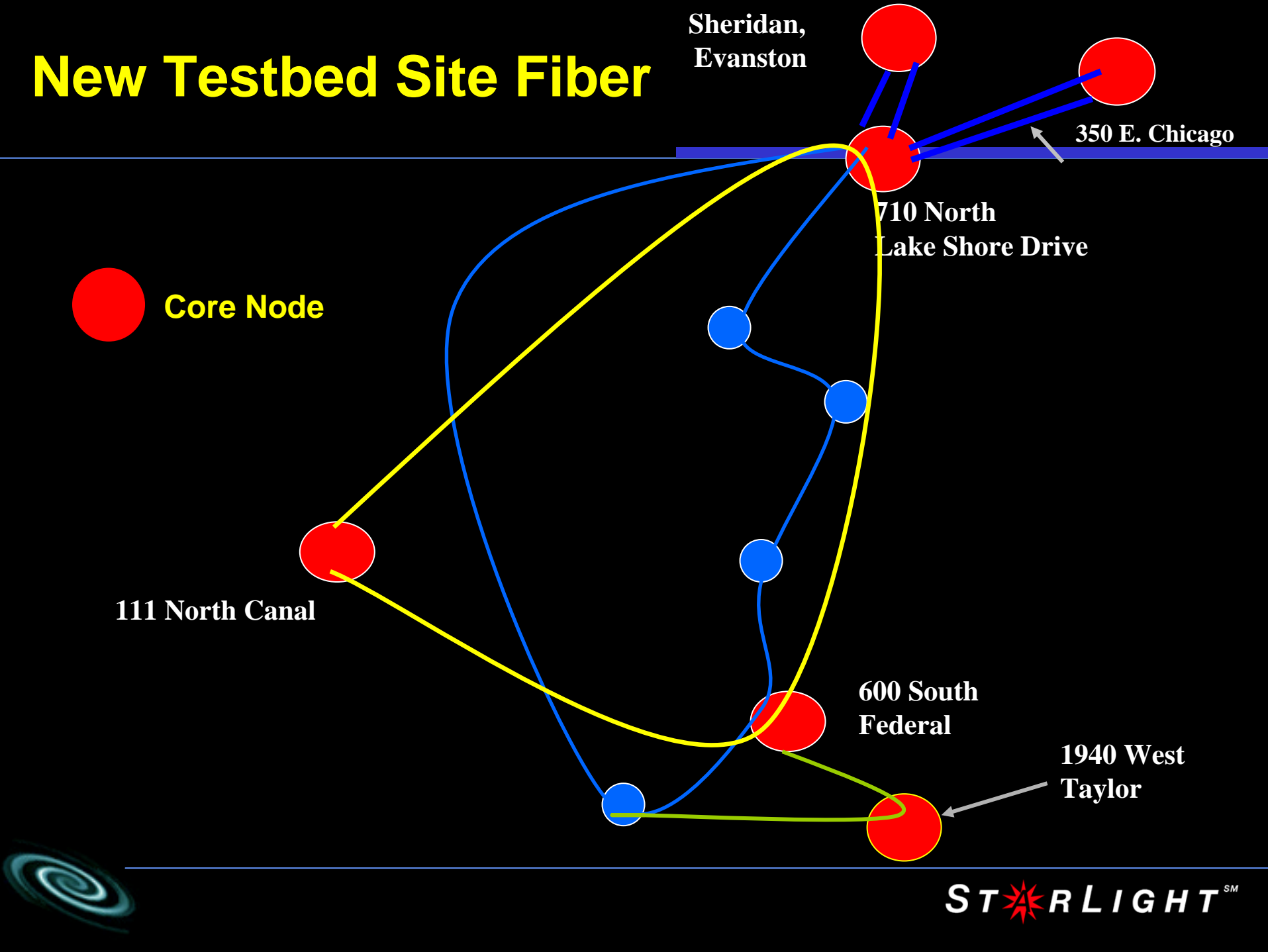
Sheridan, Evanston

350 E. Chicago

710 North
Lake Shore Drive

Core Node

111 North Canal

600 South
Federal

1940 West
Taylor
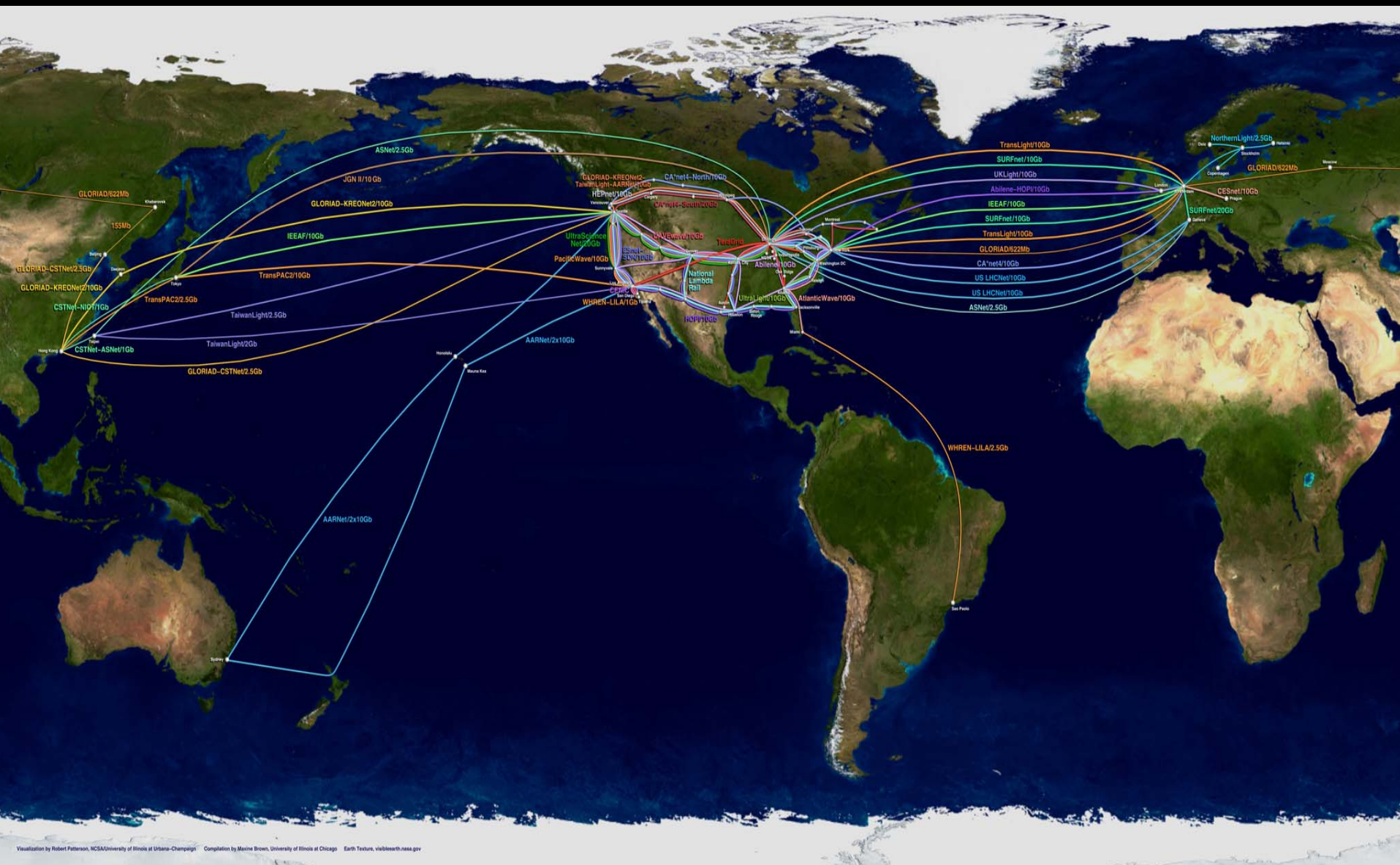
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# StarLight – "By Researchers For Researchers"

**StarLight is an experimental optical infrastructure and proving ground for network services optimized for high-performance applications GE+2.5+10GE Exchange**

**Soon: Multiple 10GEs Over Optics – World's "Largest" 10GE Exchange!**



**View from StarLight**



**Abbott Hall, Northwestern University's Chicago downtown campus**

**S T ★ R L I G H T** ℠

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www.comsoc.org

*MAGAZINE*

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**Radio Communications**

**Topics in Network and
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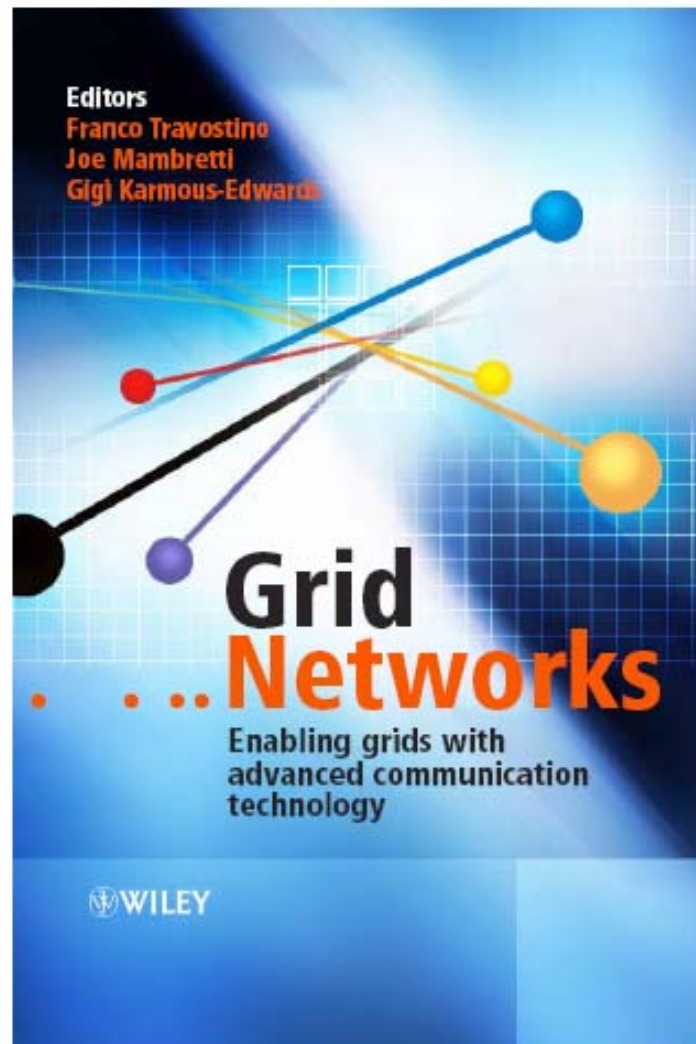### & APPLICATIONS

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